INSTRUCTION MANUAL

REGATRON

POWER SUPPLY

MODEL 218A/218A

SERIAL No. _____

ELECTRONIC MEASUREMENTS COMPANY, INCORPORATED

EATONTOWN · NEW JERSEY

TELEPHONE: (201) Liberty 2-0300 TWX: (201) 542-2273 CABLE: ELMEASCO

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2. On receipt of shipping instructions, forward the appartus to us, prepaid, and we will make repairs and adjustments immediately at the factory.

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INSTRUCTION MANUAL

REGATRON
PROGRAMMABLE
POWER SUPPLY

MODEL 2181AM

SERIAL NO. _____

ELECTRONIC MEASUREMENTS COMPANY, INC.
EATONTOWN, NEW JERSEY

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E/M* REGATRON POWER SUPPLY

TABLE OF SPECIFICATIONS

MODEL	DC OUTPUT		INPUT POWER REQUIRED IN WATTS	DIMENSIONS IN INCHES			APPROX. WEIGHT IN LBS.
	VOLTS	AMPERES		PANEL HEIGHT	PANEL WIDTH	DEPTH BEHIND PANEL	
215A	0-50	0-3	992	10-1/2	19	16-3/4	77
218A	0-100	0-3	1155	10-1/2	19	16-3/4	77

REGULATION
LINE: 0.06% or 0.03 volt, whichever is greater, for line change from 105 to 125 volts ac, 50-60 cps.

LOAD: For Model 215A, 0.1%, or 0.03 volt; for Model 218A, 0.04% or 0.03 volt; whichever value is greater, from no load to full load.

REGULATION WITH CHOPPER STABILIZATION
LINE OR LOAD: 0.01% or 3 millivolts, whichever is greater.

STABILITY: Within 0.1% or 50 millivolts, whichever is greater, for 8 hours after 30-minute warmup under fixed line, load, and temperature conditions, and using precision high-stability external programming resistor.

STABILITY WITH CHOPPER STABILIZATION: 0.05% + 2 millivolts, same as conditions above.

RIPPLE: 1 millivolt RMS maximum with positive or negative output grounded.

OUTPUT IMPEDANCE: Less than 0.01 ohm at low audio frequencies; 0.1 ohm to 10KC; 1 ohm to 40KC.

TRANSIENT RESPONSE: For step change from no load to full or full to no load, output recovers to within dc regulation limits of initial value within 1 millisecond.

PROGRAMMING CONSTANT: 1000 ohms-per-volt of output.

REMOTE SENSING: Panel terminals permit sensing of positive and negative output leads.

AMBIENT TEMPERATURE RANGE: -20°C to +45°C.

CASE GROUND: Positive, negative or floating output.

CIRCUIT PROTECTION: Input ac line fused, dc output fused.

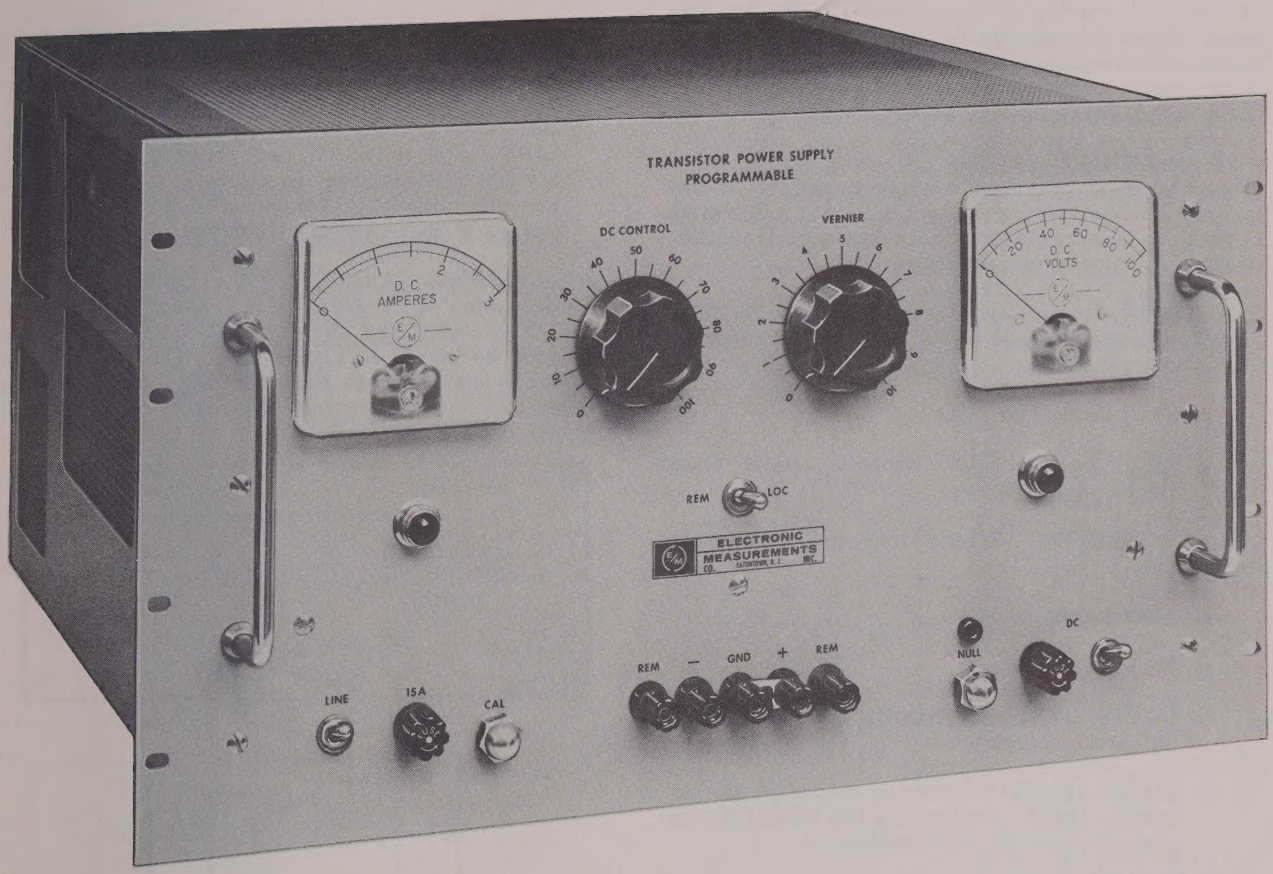
TERMINATIONS: Front: 5-way insulated binding posts. Rear: barrier-type terminal strips. Line cord is 3-conductor type.

CONTROLS: DC CONTROL and VERNIER are wirewound type. Panel calibration is approximate.

MOUNTING: Unit fits 19-inch standard rack and is equipped with rubber feet for table mounting. Top and bottom are protected by perforated metal covers.

FINISH: Smooth gray semi-gloss enamel Class 2 per MIL-E-15090

*Registered U.S. Patent Office. Patents issued and pending.



SECTION 1

DESCRIPTION

1-1. This Regatron Programmable Power Supply is a wide-range source of voltage-regulated dc power designed for general laboratory use, for incorporation into systems, or production test applications. It is especially suitable for transistor applications requiring stable low voltages. Output is continuously adjustable from zero to maximum voltage output. A vernier permits high resolution of output down to a fraction of a volt. Further detailed performance data is presented in the Table of Specifications.

1-2. PROGRAMMING. The output voltage of this power supply can be controlled remotely, or programmed, with a resistor connected to the REM and + terminals. Output voltage then depends directly on the value of the programming resistor at a constant ratio of 1 volt per 1000 ohms. This ratio remains constant over the entire output voltage range, even at a fraction of a volt. Refer to paragraph 2-9 for instructions on programmed operation.

1-3. CONSTANT-CURRENT OUTPUT. This power supply can be converted from constant-voltage to constant-current output by means of simple external connections. Refer to paragraph 2-17.

1-4. CHOPPER STABILIZATION. This manual covers both the standard and the chopper-stabilized versions of this power supply.

SECTION 2
OPERATION

2-1. INSPECTION. Before placing the power supply in operation inspect the interior and check that all tubes are seated securely in their sockets. The top dust cover slides off towards the rear when the holding screws have been removed. Damage incurred in shipment should be handled in accordance with the instructions on the Warranty page of this manual.

2-2. INSTALLATION. This unit operates on 105 to 125 volts, 50-60 cps, single-phase ac power. It may be rack-mounted or used on a table. Top and bottom covers can be removed for increased air circulation under high ambient temperatures.

2-3. FUSES. Replacement fuses must be of the same values as indicated on the panel. This unit contains the following fuses mounted on the front panel:

a. F1 in the ac line input.

b. F2 in the + dc output; protects against short circuit or overloads.

2-4. PRELIMINARY. Before connecting ac line cord check that:

a. LINE switch is off.

b. DC switch is off.

c. DC CONTROL and VERNIER are at minimum, fully counterclockwise.

d. LOCAL/REMOTE switch is at appropriate position; LOCAL for panel control, REMOTE for remotely programmed operation.

e. Swinging link is at desired grounding position, or disconnected for floating output.

2-5. LINE AND LOAD CONNECTIONS. Connect line cord to ac power outlet. Connect load to + and — output posts. Load wires should be heavy enough to prevent substantial IR drops between output posts and load in order to maintain the specified regulation of the power supply in actual service. The remote sensing connection described in paragraph 2-7 permits compensation for IR drops in load wires.

2-6. LOCAL OPERATION.

a. Throw LINE switch on. Green indicator should light.

b. Set DC CONTROL to the desired voltage as indicated on the panel or voltmeter. This can be a coarse setting. If greater resolution is desired the VERNIER, which is additive, can provide the fine setting.

c. Turn VERNIER to precise voltage desired. For an output of 30 volts or less, set DC CONTROL to zero and select output with VERNIER alone to realize greater stability.

d. Throw DC switch to on.

NOTE

A time delay relay inserted in the primary input circuit of this supply, automatically controls the warm-up time for this equipment when the LINE switch is thrown, thus preventing excess voltage to the load during warm-up time. Subsequently, the DC switch can be on or off with no danger of exceeding the desired output voltage.

2-7. REMOTE SENSING. For remote sensing for compensation of IR drops in the output leads, throw the LOCAL/REMOTE switch to REMOTE and connect the load as shown in Figure 2-1. The sense leads should be connected to the terminals on the load in order to realize the rated regulation of the power supply at the load.

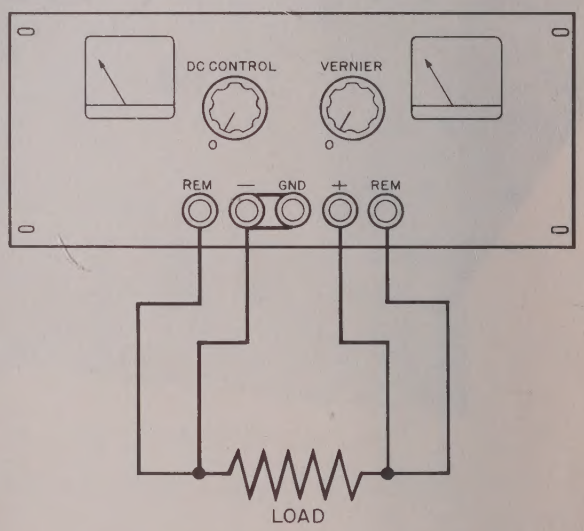


Figure 2-1.
Remote Sensing Connections, Local Operation

2-8. USE OF REAR TERMINATIONS. On units equipped with rear-mounted terminations only, the preceding operation instructions apply without change. On units equipped with both front and rear terminations, the following additional procedure applies to local operation from the rear terminals:

a. Throw LOCAL/REMOTE switch to REMOTE.

b. On rear terminal board, connect REM posts to adjacent output posts.

In remotely programmed use, either set of terminations can be employed in the normal manner as described in paragraphs 2-9 and 2-10. Control will then be derived from the set of terminals in use.

2-9. PROGRAMMED OPERATION. As stated in para-

graph 1-2, the output of this power supply can be controlled from a remote point, or programmed, with a resistor. For programmed operation, proceed as follows:

a. Throw DC and LINE switches off.

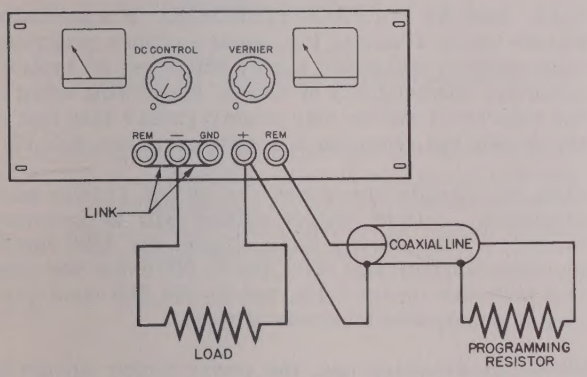
b. Throw LOCAL/REMOTE switch to REMOTE.

c. Connect the load and programming resistor as shown in Figure 2-2A. Output voltage depends on programming resistance in the ratio 1: 1000. For example, to obtain 50 volts, use a 50,000-ohm resistor.

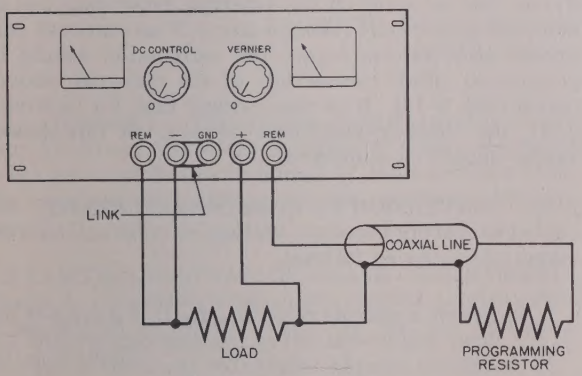
d. Throw LINE switch on.

e. Set DC CONTROL and VERNIER to zero.

f. Throw DC switch on. Programmed voltage is now applied to load.



A. Local Sensing



B. Remote Sensing

Figure 2-2. Programmed Operation

2-10. REMOTE SENSING, PROGRAMMED USE. Where load and control resistors are far from the unit but near each other, the method of Figure 2-2B will eliminate the effect of voltage drops in the output leads, yielding remote sensing for regulation at the load.

2-11. PROGRAMMING CONSIDERATIONS. The following considerations should be carefully noted before programming this power supply.

a. An open in a remote control circuit is effectively a high programming resistance and, accordingly, will cause an uncontrolled voltage rise to maximum output. To avoid damage to the load or repeated blowing of the dc fuse, provision should be made to prevent opens. For the same reason, it is necessary that make-before-break switches be used in any multiple-voltage programming arrangement, as in Figure 2-3.

b. Unless the programming resistor itself is physically shunted across the REM and + terminal posts, it is desirable to use shielded or coaxial cable, as shown in Figure 2-2A, to prevent injection of ripple and noise from external sources. An insulated cable such as RG58/U is recommended because the coaxial sheath carries output potential.

c. For long term or permanent programmed operation, it is advisable to short out the internal controls. This will eliminate possible disturbance of programmed voltage by accidental rotation or vibration of the DC CONTROL or VERNIER.

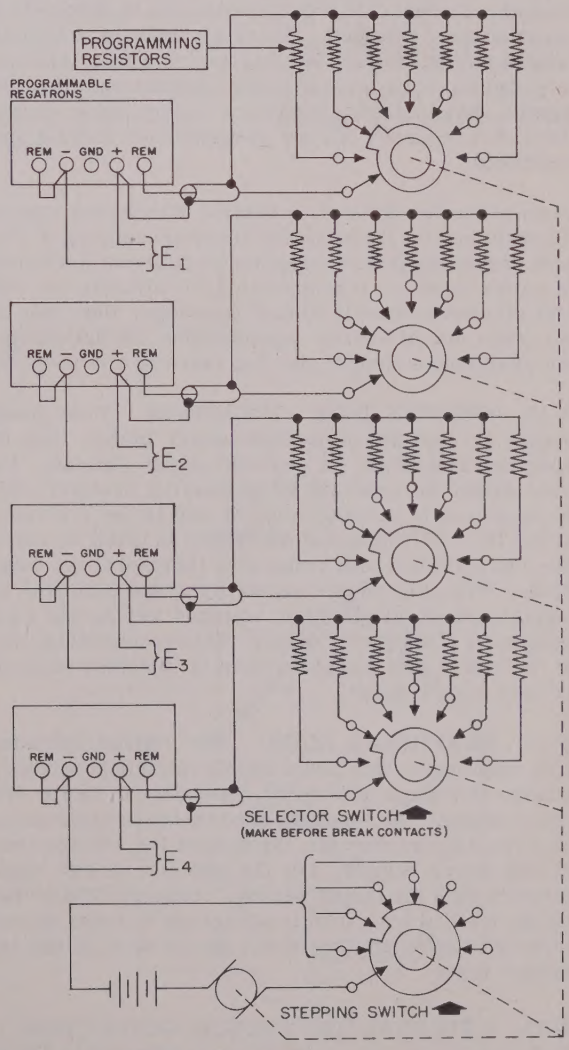


Figure 2-3. Programming With Stepping Switch

d. Programmed operation can be combined with use of the internal controls when convenient or necessary by merely omitting step e, paragraph 2-9, and adjusting controls to any desired value. In this case, the value of the programming resistor will be added to the values to which the internal controls are adjusted, and the total resistance will determine the output voltage.

2-12. PROGRAMMING SUGGESTIONS. Although the above programming instructions are illustrated with a single fixed resistor as the remote control, it is evident that variable resistors, driven potentiometers, or fixed resistors wired to stepping switches can be employed to deliver voltages in a wide variety of time/amplitude patterns.

The time required for switching from one programmed voltage to another varies from the seconds range to the milliseconds range, depending upon conditions. Modifications for special switching times are available on special order from the factory.

It is also evident that programming can be manually or automatically actuated. As an example of automatic programming, Figure 2-3 illustrates a four level rotary switch, each level of which controls one Regatron supply. As illustrated, the entire battery can be stepped through a sequence of four programmed outputs upon command.

In an extensive system, a central board may contain the switches or rheostats for the programming of several Regatron power supplies in different locations. In such a system, it is practical to calibrate the control elements directly to dial markings. Note that the accuracy of calibration depends upon the accuracy of the resistances and/or the dial markings.

2-13. OVERVOLTAGE OPERATION. This power supply is capable of voltage output higher than the specified maximum, at reduced output current. For overvoltage an external programming resistor must be employed to substitute for or add to the resistance of the DC CONTROL and VERNIER in order to extend the control resistance range and, therefore, the output range. The overvoltage capability graph indicates the output current available at voltages beyond the rated maximum of the power supply. This graph will be found at the end of this manual or can be obtained from the factory upon request.

2-14. REFERENCE AGING. The voltage reference tube employed in this power supply exhibits progressive change of voltage with aging, typically, 0.5% for 1000 hours of use. The resulting error at the output remains at a constant percentage throughout the voltage range of the power supply, but the absolute error varies directly with the output setting. Periodic calibration by the method described in paragraph 4-4 may be performed to eliminate any error due to aging of the reference tube.

2-15. EXTERNAL REFERENCE CONNECTION. If higher accuracy is required than is provided by the internal reference, a stable external reference source of at least 85 volts can be employed. The external reference source, which should be capable of at least 1 milliampere, is connected via the rear-mounted terminal board TB1 as follows:

a. Remove the link across terminals 1 and 2 of TB1.

b. Connect the external reference across terminals 2 and 3 with the positive at terminal 3.

An external reference between 85 and 87 volts may be directly connected as described. Above 87 volts, each additional volt requires the insertion of 1000 ohms of resistance between the external reference and terminal 3 on TB1 of the power supply. Thus, an external reference of — 150 volts requires a resistor of 63,000 ohms ±1%. The resistor should be a wirewound type using high stability alloy, since it directly affects the stability of the output voltage from the power supply.

2-16. USE AS VOLTAGE STANDARD. If a precision decade box is available for use as a remote programming control, this power supply will serve as a voltage standard, the accuracy of which, (neglecting aging of the reference) will be only slightly poorer than that of the decade box, even for a decade accuracy of 0.1%.

With the decade box connected as the remote programming resistor, output voltage will be indicated directly by the decade dials. Thus, the 1000 ohms-per-step dial indicates volts, the 10,000 ohms-per-step dial indicates tens of volts, and the 100,000 ohms-per-step dial indicates hundreds of volts.

In voltage-standard use, the power supply should be calibrated as described in paragraphs 4-5 and 4-6. Error due to aging of the internal reference can be nullified by periodic recalibration. If an external reference is to be employed, the calibration should be performed after connection of the external source (paragraph 2-15). It is also evident that, for minimum drift, the chopper-stabilized version of this power supply should be employed.

2-17. CONVERSION TO CONSTANT-CURRENT. For conversion from constant-voltage to constant-current output, proceed as follows:

a. Select a sample resistor, R_S in Figure 2-4 below, which will carry the load current and develop a sample voltage for the control system. To determine its value, select a sample voltage. 5 to 10 volts is a good range. Although the voltage may be made as high as desired it must be remembered that the sample voltage subtracts from the available output voltage. If E_S is the sample voltage and I_L is the desired load current, then $R_S = E_S/I_L$, where R_S is in ohms and I_L is in amperes. The actual wattage will be $E_S \times I_L$. The resistor used should have a somewhat higher wattage rating.

b. Make connections as shown in Figure 2-4 and set both panel controls to zero.

c. Throw LOCAL/REMOTE switch to REMOTE.

d. Throw the LINE switch on.

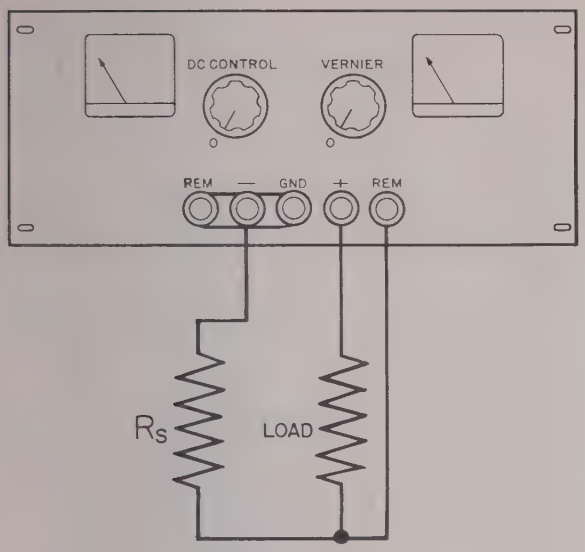


Figure 2-4.
Conversion to Constant-Current Operation

e. Bring current up to the desired value by turning the VERNIER up to the voltage selected as the sample in step a, above. In constant-current operation the VERNIER is the output control (for sample voltages up to 10 volts).

The conversion described above provides good dc regulation. The ac impedance of the power supply, however, is relatively low, and this should be noted in considering applications.

2-18. CHOPPER-STABILIZED OPERATION. As stated in the Table of Specifications, this unit achieves regulation of 0.01% or 3 millivolts, and stability of 0.05% + 2 millivolts for 8 hours when equipped with chopper stabilization. Although both ratings are conservative, note that the stability figure is specified with the unit in programmed operation, using an external resistor of high electrical and (in the case of a variable resistor) high mechanical stability. This rating can be realized only in such operation, and with the internal controls shorted out or set to zero to prevent them from accidental rotation or vibrations.

2-19. CURRENT LIMITER. A current limiter is used to prevent an uncontrolled rise in output current from the supply in the event of a short circuit load or overload. The LIMITER CURRENT control dial markings represent the maximum current available into a short circuit load. It should be noted that in the short circuited load condition, and, actually, at load resistances approaching a short circuit, voltage output decreases and the power supply reverts, in effect, to constant-current output of moderate regulation. This change-over occurs at the so-called "knee" of the EI curve, with the quality of the amplifiers within the regulator system of the supply determining the sharpness of the "knee".

SECTION 3
CIRCUITRY

NOTE: Circuit references are made to the schematic diagram, except where indicated.

3-1. GENERAL. This power supply employs a full-wave rectifier, the positive output of which is applied to series amplifiers controlled by the regulator loop. The resulting regulated dc voltage constitutes the output.

3-2. CONTROL SYSTEM, LOCAL AND PROGRAMMED. Figure 3-1 illustrates the output control configuration in simplified form. If inputs G_1 and G_2 are equal ($E_D = 0$) then:

$$\frac{E_o}{E_R} = \frac{R_1}{R_2} \text{ and } E_o = E_R \times \frac{R_1}{R_2}$$

where E_o = regulated output voltage
E_R = internal reference voltage
and R_2 is a fixed resistor.

Since E_R and R_2 are constant, $E_o = KR_1$; or, the output voltage is dependent only upon the value of R_1 which in local operation of the power supply, consists of the DC CONTROL and VERNIER. In programmed operation, R_1 is the remote programming resistor. In either local or programmed operation, the voltage output equals $0.001R_1$, or 1,000 ohms control resistance per volt of output.

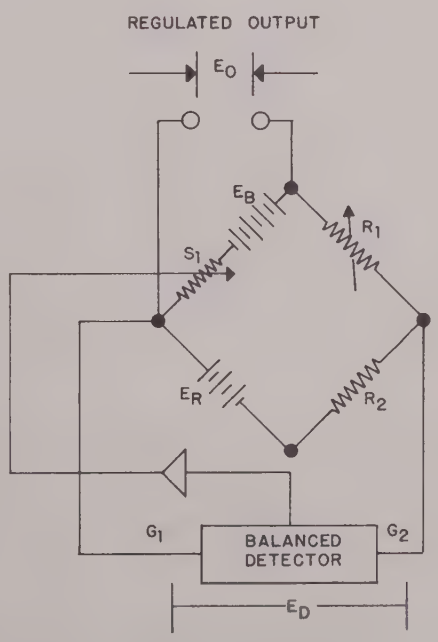


Figure 3-1. Output Control Configuration

In practice, R_2 can be adjusted with the CAL control (on the panel) for exact 1000 ohms-per-volt programmed operation, or to calibrate output with panel dial markings.

3-3. REGULATOR SYSTEM. The regulator system employs a balanced input detector, V11, connected from the zero point of the input bleeder to the negative reference point to detect departures from balance. The amplifier error is applied to a high gain amplifier, V10, the output of which is applied to a cathode follower, V9, for sufficient current gain to drive the grids of series amplifiers V12 through V29 in a manner such as to overcome the error. Because of the high gain of the system the error at equilibrium is very small. Reference tube V7 maintains a very stable reference potential. Gas tube V8 preregulates the potential at the cathode of V10, and gas tubes V3 through V6 maintain steady potential for the tubes of the regulator system.

3-4. UNREGULATED SUPPLY. The main dc supply employs mercury vapor rectifier tubes V1 and V2 in a full-wave connection, with filtering by capacitors C1, C2, and C3. Bleeder resistor R1 discharges the filters upon turn-off of the power supply. A full-wave bridge of silicon rectifiers CR1 through CR4 comprise the screen supply for the series amplifiers, with filtering by C4. This screen supply, the negative of which is returned to the cathodes of the series amplifiers, also serves as plate supply for cathode follower V9 and high gain amplifier V10. Rectifiers CR8, CR9, and CR10 deliver negative dc potential for the reference system, with filtering by C6. Rectifiers CR5, CR6, and CR7 deliver positive dc potential for the plate of V11 and the chopper-stabilizer amplifier, when installed.

3-5. REFERENCE. The internal reference potential for the regulator of the power supply is obtained by three stages of regulation of the potential from rectifiers CR8, CR9, and CR10. The regulated -150 volts from VR tube V5 is further regulated at 108 volts by tube V6 for service at the cathodes of the balanced input detector, V11. Further preregulation at -85 volts for the cathode of amplifier V10 is accomplished by tube V8. The stable reference potential of -85 volts utilized at the output control configuration shown in Figure 3-1 is developed by another gas-filled tube, V7. CAL control R20, in the input bridge, permits calibration of the control system to a precise output voltage based upon the exact potential across V7, and permits periodic recalibration to eliminate error resulting from aging of V7. When an external reference is employed (refer to paragraph 2-15), tube V7 is disconnected from the control system by the removal of the link across terminals 1 and 2 on TB1.

Diode CR12 functions as a one-way switch. CR12 disconnects V6 from the junction of R8 and R9 to permit momentary application of the high firing potential through R12. As soon as V6 has fired, CR12 closes the path from the junction of R8 and R9, permitting normal flow through V6 and clamping the momentary firing potential.

Positive service potentials are regulated at 150 volts by V3 and at 108 volts by V4 for application to the plates of V11. Diode CR11 functions in the same manner as CR12 for tube V4.

3-6. SERIES AMPLIFIERS. Paralleled beam power pentodes V12 through V29 are employed as series elements, or variable conductances. Control grids are direct coupled to the output of cathode follower V9. The cathodes of the series amplifiers, from which positive regulated output voltage is obtained, are removed from the + output terminal when DC switch S2 is thrown off. The DC switch also shorts the + and — terminals to protect the load from surges during standby operation. Resistor R25 provides a path for the small amount of plate current which continues to flow when the series amplifiers are biased to cutoff for zero voltage output from the power supply.

3-7. BALANCED INPUT DETECTOR. Cathode-detector. Grid 1 (pin 7) is effectively at the zero point of the control bridge (positive of the reference potential) and grid 2 (pin 2) at the other zero point on the opposite side of the control bridge. Regulated plate supply is taken from V4 and cathodes are returned through R17 to -108 volts regulated by V6. NULL control R18 permits setting of the balanced input detector to zero difference between grids. Capacitor C9 bypasses degenerative ac components appearing across R18.

Output from plate 1 (pin 6) of V11 is applied across a coupling and voltage divider network consisting of glow discharge regulator tubes V30 and V31 and resistors R15 and R16. These tubes couple plate potential to the grid of V10, maintaining a constant voltage drop which permits the grid to follow the potenital at the plate of V11. This constitutes an effective dc coupling which avoids any substantial loss of gain.

Note that the chopper-stabilized version of this power supply employs a 12AY7 in place of the 12AX7 for tube V11. Standard models include ballast regulator RT1 to maintain a stable 6.3 volts ac across the heater of V11. The ballast is not required in the chopper-stabilized version and the RT1 socket is therefore employed for the chopper stabilizer unit with slight wiring changes shown on the schematic diagram.

3-8. DRIVER AMPLIFIER AND CATHODE FOLLOWER. This stage employs pentode V10 in high gain, low current operation. Output is direct-coupled to the grids of cathode follower V9, which employs both sections of a dual-triode in parallel. Output from V9 is direct-coupled to the control grids of the series amplifiers, completing the regulator system loop.

3-9. CHOPPER STABILIZER. On units so equipped, the chopper stabilizer continuously corrects for zero-offset in the balanced detector, thereby eliminating output drift from this cause. Connected across the grids of balanced input detector V11, the chopper stabilizer continually samples the offset at grid 2 (pin 2), chops it to produce a square wave, amplifies, rectifies, and filters it, and applies the resulting correction signal to grid 1 (pin 7) to reduce the net offset to a vanishingly small value. Without the chopper stabilizer this stage is subject to drift to the extent that output voltage may change up to 0.1% or 50 millivolts for 8 hours. With chopper stabilization, stability becomes 0.05% + 2 millivolts which represents a ten-to-fifty times improvement at low voltages where divider action by the control bridge makes zero offset, in

an unstabilized system, the major source of drift. The chopper stabilizer adds a gain of approximately 1000 to the regulator system. Both regulation and stability improve as shown in the Table of Specifications.

3-10. CURRENT LIMITER. The current limiter utilizes both sections of a type 12AX7 tube, a pnp transistor, and associated components. A resistor which develops a 4-volt drop at maximum rated current is inserted into the negative output line of the main dc supply to serve as a sampling resistor. One side of the resistor is connected to the grid of one section of the 12AX7 through the LIMITER CURRENT control. The signal at the cathode, pin 3, follows the voltage fluctuations sensed by the grid in an almost one-to-one correspondence, and this signal is applied at the emitter of the transistor. The base of the transistor is connected through a 10K limiting resistor to the other side of the sampling resistor. Thus the transistor operates with base-emitter potential which effectively equals the voltage drop across the sampling resistor. The resulting signal at the collector is applied to the grid of the second section of the tube, the cathode-follower output of which goes to the control grid of high gain amplifier V10.

When output current is below the limiter setting, the voltage drop across the sampling resistor is such that the emitter of the transistor is negative with respect to the base, and the transistor is therefore turned off. In this condition, the second cathode-follower tube section is turned sufficiently off so that it has no effect on tube V10.

When output current rises to the limiter setting, the emitter of the transistor becomes more positive with respect to the base. The transistor is thereby turned on and, by the same signal path previously described, takes control of tube V10, driving the regulator system to equilibrium at the current limiter setting.

3-11. OUTPUT CIRCUITRY. Capacitor C10 is connected across the output terminals to improve transient behavior, to lower the ac output impedance of the power supply, and to adjust the characteristic of the feedback regulator loop for stable operation. Also across the output is Diode CR13 which protects the external load by presenting a low impedance to any reverse voltage that may develop when the unit is shut off. Glow lamp DS3 serves as a clamp to protect internal reference tube V7 from voltage surges when the power supply is switched from high to low voltage in remote control (programmed) operation. DS3 fires momentarily but is otherwise normally inoperative. It should be noted that throwing the LOCAL/REMOTE switch to REMOTE removes the positive side of the reference from the minus side of the high voltage output. This connection is re-established via the programming connections shown in Figure 2-2.

SECTION 4
MAINTENANCE

Attention is called to the Warranty under which this equipment is sold, to be found at the front of this manual.

4-1. PARTS REPLACEMENT. The electrical parts list and schematic diagram at the end of this book should be employed to identify all parts to be replaced. In general, replacement parts are completely defined by the values and tolerances indicated on the parts list. The following components, however, require special attention:

a. V3, V4, V5, V6, V7, and V8. Replacement of any of these tubes will affect null balance, which should therefore be readjusted as per paragraph 4-2.

b. V7. Replacement of this tube will change the internal reference voltage somewhat, and will necessitate recalibration as per paragraph 4-4.

c. DC CONTROL and VERNIER controls. If either of these wirewound potentiometers is defective, it is advisable to obtain an exact replacement. If none is available locally, an order should be addressed to the factory. Any temporary substitute potentiometer should provide an arc of 280° effective rotation for the panel dial markings to correctly represent the output.

4-2. NULL ADJUSTMENT. The NULL control, located on the front panel, permits adjustment of the balanced input detector to null, or zero level. This adjustment which holds over the entire operating range, is made as follows:

a. Remove the acorn nut covering the control.

b. With the DC CONTROL and VERNIER at zero, throw the LINE and DC switches on. After a minute (from cold start) throw the DC switch on.

c. Connect a voltmeter across TP1 (J1) and the negative REM terminal. Use 3-volt dc scale or lower.

d. Adjust the NULL control for zero on the meter. A very sensitive indication can be obtained by alternately connecting and disconnecting the meter lead.

4-3. NULL ADJUSTMENT FOR CHOPPER-STABILIZED UNITS. The NULL control on the chopper-stabilized version should be set to maximum resistance for optimum operation. No attempt should be made to adjust the NULL control to zero, as described above, with the chopper stabilizer unit removed.

4-4. CALIBRATION. The CAL control, also found on the front panel, requires adjustment for any one of three reasons:

a. For close agreement between panel markings and output.

b. For exact 1000 ohms-per-volt ratio in programmed output.

c. For recalibration to either of the above upon aging or replacement of V7.

CAL control adjustment can be performed with either a voltmeter or an external, precise voltage source.

4-5. If an accurate voltmeter is employed, proceed as follows: (See Figure 4-1A.)

a. Remove acorn nut covering CAL control. Connect meter across + and — terminals.

b. To calibrate panel markings turn VERNIER to zero and DC CONTROL to maximum panel marking. Place unit in operation and adjust CAL control for maximum voltage output of the power supply as indicated on the external voltmeter.

c. To calibrate for exact 1000 ohms-per-volt programming constant, turn VERNIER and DC CONTROL to zero and set up the power supply for programmed operation using a programming resistor of the appropriate value to develop maximum output voltage. Place the unit in operation and adjust the CAL control for the maximum rated voltage of the power supply as indicated on the external meter.

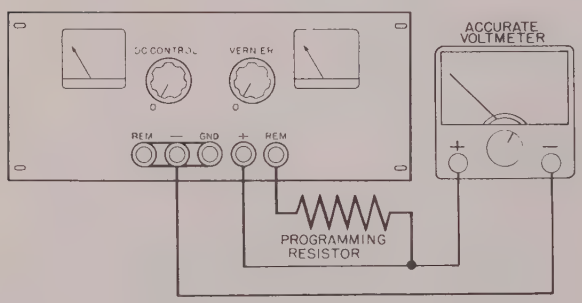


Figure 4-1. Calibration With Voltmeter For Exact 1000 Ohms-per-volt Programming

4-6. If an external, precise source of voltage is employed, proceed as follows: (See Figure 4-1B.)

a. Connect the negative outputs of the unit and the external voltage source together.

b. Connect a voltmeter between the positive terminals of the power supply and the external source.

c. Set the external source to the exact minimum rated voltage output of the power supply.

d. To calibrate panel markings perform step c, turn VERNIER to zero and DC CONTROL to maximum panel marking. Place unit in operation and adjust CAL control for a zero reading on the external voltmeter. Use the lowest dc range available.

e. To calibrate for exact 1000 ohms-per-volt programmed output perform step c, turn VERNIER and DC CONTROL to zero, and set up the power supply for programmed operation using a programming resistor of the appropriate value to develop maximum output voltage. Place the unit in operation and adjust CAL control for zero on the external meter.

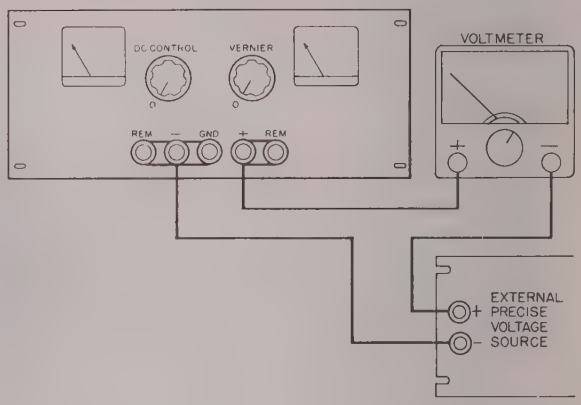


Figure 4-2. Calibration With External, Precise Voltage Source

4-7. SERIES TUBE FAULTS. In selecting replacement series tubes, or when a malfunction appears to result from a faulty series tube, the following procedure is recommended:

a. Remove all series tubes but one.

b. Turn on unit, apply 1/N of full load current at low voltage, where N = number of series tubes.

c. Check ripple and regulation.

d. Remove the remaining series tube, place another series tube in another socket, and repeat steps b and c. Repeat steps b and c for every other socket and tube, taking one at a time.

e. If one or more series circuits tests faulty, repeat the test in each case with a tube known to be satisfactory. If the repeated test proves favorable, it may be assumed that the previous tube is defective. Otherwise the associated circuit should be checked for faults.

4-8. CLEANING AND LUBRICATION. This power supply employs forced air cooling. After extended service, considerable dust will be deposited on most surfaces within the unit. About twice a year the cover should be removed and all parts, particularly the fan blades, should be cleansed free of dust and grime. Lubricate the fan motor once or twice a year by squeezing a few drops of light machine oil into the lubrication holes of the bearing straps.

4-9. TROUBLE SHOOTING. Referenced below are several symptoms of faults which could develop in this power supply. Opposite each symptom is the most likely cause and remedy. The table is intended as a guide to trouble shooting.

SYMPTOM	CAUSE	REMEDY
Unit is dead when LINE switch is thrown.	Fuse F1 blown or defective.	Replace F1.
Fuse F1 blows repeatedly.	Rectifier CR1 through CR10 shorted.	Check rectifiers and replace if defective.
DC fuse F2 blows, output to zero.	Short circuit load.	Check load.
	Overload above current rating of power supply.	Check load.
	Fuse F2 defective, open.	Check for continuity and replace F2 if necessary.
	With load connected, DC CONTROL or VERNIER potentiometer is open.	Measure resistance of potentiometers. Refer to paragraph 4-1.
	With load connected, remote control line (programming line) is open.	Check remote control line for open.
	Diode CR13 shorted	Replace CR17.
	Series amplifier tube (starting with V12) shorted with load connected.	Replace defective tube. Refer to paragraphs 4-1 and 4-7.
No control of output, voltmeter pins at top of scale.	Series amplifier tube (starting with V12) shorted.	Replace defective tube. Refer to paragraphs 4-1 and 4-7. Also check screen and cathode resistors of affected stage.
	Amplifier V1 defective.	Replace V10.
	DC CONTROL or VERNIER open.	Check and replace. Refer to paragraph 4-1.
	Programming resistor or line open, in programmed operation.	Check programming resistor and line.
No control of output, voltmeter at zero, fuse F2 not blown.	Balanced input detector V11 defective.	Replace V11. Refer to paragraph 4-1.
	Ballast tube RT1 defective.	Replace RT1.
	Open filament on tube V9 or V11.	Replace V9 or V11.
Voltmeter indication disagrees with control settings at full scale.	Unit out of calibration.	Recalibrate.
Output voltage lower than control setting but recalibration impossible or out of CAL range.	Reference tube V7 has shifted voltage.	Replace V7. Refer to paragraph 4-1. Also recalibrate.
Output voltage lower than control setting in chopper-stabilized unit.	Tube (12AX7) in chopper-stabilizer unit defective.	Replace tube.

SYMPTOM	CAUSE	REMEDY
Poor line regulation	Defective tube V3, V4, V5, V6, V7, V8 or V11.	Replace defective tube. Refer to paragraph 4-1.
	Defective rectifier V1 or V2.	Replace V1 or V2.
Poor load regulation.	Poor load connections or high resistance in load leads.	Check load connections.
	Chopper inoperative.	Replace chopper.
Excessive zero-offset(drift) in chopper-stabilizer unit.	Tube V11 defective.	Replace V11.
	Chopper inoperative.	Replace chopper.
NULL adjustment impossible.	Fuse F2 blown.	Replace F2.
	Defective tube V3, V4, V5, V6, V7, V8, V11, V30 or V31.	Replace defective tube.
High ripple.	In programmed operation, programming resistor or control line are coupling stray ac signal to power supply.	Shield programming resistor and/or control line.
	Defective tube V5, V6, V7, V8, V9, V10 or V11.	Replace defective tube.
	Defective capacitor C1, C2, C3, C4, C5, C10 or C11.	Replace defective capacitor.
DC output changes abruptly	Defective tube V1, V2, V3, V4, V5, V6, V9 or V10.	Replace defective tube. Recalibrate if V6 is replaced.

4-10. VOLTAGE AND RESISTANCE TABLES. Voltage and resistance values in the table supplied with this manual are nominal and may vary as much as 20% among production units without causing difficulties. The conditions of measurement are as follows:

For resistance measurements:

a. AC line cord not connected to power.

b. No load connected.

c. LINE and DC switches off. Floating output (swinging link disconnected from + or — post). LOCAL/REMOTE switch at LOCAL.

d. DC CONTROL and VERNIER at zero.

e. Readings from indicated tube pins to — (minus) output post.

For voltage measurements, using 20,000 ohms-per-volt meter:

a. Line input 115 volts ac. LINE and DC switches on.

b. VERNIER at maximum and DC CONTROL at correct additive setting for maximum rated voltage output.

c. No load connected.

d. Floating output (swinging link disconnected from + or — output post). LOCAL/REMOTE switch at LOCAL.

e. Readings from indicated tube pins to — (minus) output post.

MODEL 215A

RESISTANCE										VOLTAGE									
	PIN									PIN									
TUBE	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	TUBE
V1	20K	NC	NC	20K	-	-	-	-	-	150	NC	NC	510	-	-	-	-	-	V1
V2	20K	NC	NC	20K	-	-	-	-	-	150	NC	NC	150	-	-	-	-	-	V2
V3	NC	NC	NC	NC	50 meg	NC	0	-	-	NC	NC	NC	NC	150	NC	0	-	-	V3
V4	NC	NC	NC	NC	50 meg	NC	0	-	-	NC	NC	NC	NC	106	NC	0	-	-	V4
V5	NC	20K	NC	NC	0	NC	0	-	-	NC	-150	NC	NC	0	NC	NC	-	-	V5
V6	NC	20K	NC	NC	0	NC	NC	-	-	NC	-106	NC	NC	0	NC	NC	-	-	V6
V7	NC	NC	NC	46K	0	NC	NC	-	-	NC	NC	NC	-85	0	NC	NC	-	-	V7
V8	NC	NC	NC	NC	0	∞	26K	-	-	NC	NC	NC	NC	0	0	-85	-	-	V8
V9	50K	6 meg	240K	∞	∞	50K	6 meg	240K	∞	320	4.5	7.2	29	29	320	4.5	7.5	29	V9
V10	400K	40K	0	0	5 meg	200K	40K	-	-	-86	-85	0	0	4.5	-43	-85	-	-	V10
V11	50 meg	50	200K	0	0	30 meg	0	200K	2	108	0	0.67	0	0	43	0	0.4	5.8 AC	V11
V12 thru V29	NC	∞	20K	50K	240K	NC	∞	∞	-	NC	29	150	320	7.2	NC	29	50	-	V12 thru V29

MODEL 218A

RESISTANCE										VOLTAGE									
	PIN									PIN									
TUBE	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	TUBE
V1	3.5 meg	NC	NC	3.5 meg	-	-	-	-	-	185	NC	NC	185	-	-	-	-	-	V1
V2	3.5 meg	NC	NC	3.5 meg	-	-	-	-	-	185	NC	NC	185	-	-	-	-	-	V2
V3	NC	NC	NC	NC	∞	NC	0	-	-	140	NC	NC	NC	140	NC	0	-	-	V3
V4	NC	NC	NC	NC	∞	NC	0	-	-	NC	NC	NC	NC	102	NC	0	-	-	V4
V5	NC	21K	NC	NC	0	NC	NC	-	-	NC	-150	NC	NC	0	NC	NC	-	-	V5
V6	NC	22K	NC	NC	0	NC	NC	-	-	NC	-105	NC	NC	0	NC	NC	-	-	V6
V7	NC	NC	NC	25K	0	NC	NC	-	-	NC	NC	NC	-85	0	NC	NC	-	-	V7
V8	NC	NC	NC	NC	0	∞	22K	-	-	NC	NC	NC	NC	0	-10	-81	-	-	V8
V9	∞	∞	270K	∞	∞	∞	∞	270K	∞	320	60	62	0	0	320	60	62	0	V9
V10	500K	42K	0.7	1	∞	190K	42K	-	-	-82	-81	5VAC	00	59	-46	-81	-	-	V10
V11	∞	6	200K	0	0	∞	0	190K	5	103	0	0.9	0	0	30	0	0.45	0	V11
V12 thru V29	NC	∞	3.5 meg	∞	260K	NC	∞	∞	-	NC	0	185	320	60	NC	0	100	-	V12 thru V29

SECTION 5

PARTS LIST AND LOCATIONS

REFERENCE SYMBOL	DESCRIPTION	TYPE OR PART NO.	MANUFACTURER
B1	Motor, shaded pole, 115V, 50-60 CPS, 6 in. fan blade	DYAB-570-3	Barber-Colman
C1, 2, 3, 4, 10	Capacitor, electrolytic, 320 UF, 300 VDC, insl. sleeve	D31962	Sprague
C5, 6	Capacitor, electrolytic, 80 UF, 450VDC, insl. sleeve	D15911	Sprague
C7	Capacitor, mica, 100 UUF ±5%, 500 VDC	CM20B-101-J	Micamold
C8	Capacitor, mica, 220 UUF ±5%, 500 VDC	CM20B-221-J	Micamold
C9	Capacitor, electrolytic, 25 UF, 25 VDC, insl. sleeve	KE-25/25	Frako
C11	Capacitor, mylar, 0. 5 UF+20% -10%, 400 VDC	Type 211OBM	Chicago Condenser
C12	Capacitor, mica, 15 UUF ±5%, 500 VDC	CM20B-150-J	Micamold
	Line cord, 6'8"lg. #14 gauge, 3 cond. 3 prong plug	328-B-101	EMC
CR1, 2, 3, 4, 13	Rectifier, silicon	CER-71	Solitron Devices
CR5-CR10	Rectifier, selenium	8J1	Radio Receptor
CR11, 12	Diode, germanium	1N34A	Sylvania
DS1, 2	Bulb, 6. 3V, 0. 25A	44	G. E.
DS3	Bulb, neon	NE-2	EMC
E1, 2	Post, binding, red	29-3R	Grayhill
E3, 4, 5	Post, binding, black	29-3B	Grayhill
E6	Shorting link	938-L	General Radio
E7	Shorting link	141-II	Cinch Jones
F1	Fuse, cartridge, 15A	3AG15	Sightmaster
F2	Fuse, cartridge, 3A	3AG3	Sightmaster
J1, J5-J10	Tip, jack, nylon, black	105-603	E. F. Johnson
J3	Socket, 8 pin, octal (stabilizer unit or ballast tube)	9751-9	Cinch Jones
J4	Tip, jack, nylon, red	105-603	E. F. Johnson
M1	Ammeter, 0-3 ADC ±2% accuracy full scale	Model 653/A3	EMC
M2	Voltmeter, 0-50 VDC ±2% accuracy full scale (Model 215AM/AMK)	Model 653/V50	EMC
M2	Voltmeter, 0-100 VDC ±2% accuracy full scale (Model 218AM/AMK)	Model 543/V100	EMC
R1	Resistor, fixed, WW, ceramic, 20K ±5%, 5W	'Koolohm' 5KT20K	Sprague
R2, 3, 12	Resistor, fixed, comp, 1 meg ±10%, 1/2W	EB-1051	Allen-Bradley
R4	Resistor, fixed, WW, vitreous enamel, 10K ±5%, 20W	Type 'Brown Devil'	Ohmite
R5	Resistor, fixed, comp, 5. 1K ±5%, 1W	GB-5125	Allen-Bradley
R6	Resistor, fixed, comp, 390K ±10%, 1/2W	EB-3941	Allen-Bradley
R7	Resistor, fixed, comp, 330K ±10%, 1/2W	EB-3341	Allen-Bradley
R8	Resistor, fixed, comp, 5. 6K ±5%, 1W	GB-5625	Allen-Bradley
R9	Resistor, fixed, comp, 3. 6K ±5%, 1W	GB-3625	Allen-Bradley
R10	Resistor, fixed, comp, 22K ±10%, 1W	GB-2231	Allen-Bradley
R11	Resistor, fixed, WW, ceramic, 4K ±5%, 10W	'Koolohm' 10KT4K	Sprague
R13, 19	Resistor, fixed, comp, 220K ±10%, 1W	GB-2241	Allen-Bradley
R14, 15	Resistor, fixed, comp, 100K ±10%, 1/2W	EB-1041	Allen-Bradley
R16	Resistor, fixed, comp, 330K ±10%, 1/2W	EB-3341	Allen-Bradley
R17	Resistor, fixed, comp, 150K ±10%, 1W	GB-1541	Allen-Bradley
R18	Resistor, variable, WW, 3K ±5%, 2W, linear taper, 1/4 in. dia., 1/8 in. lg, slotted shaft, series 43	CM18923	Clarostat
R20	Resistor, variable, WW, 10K ±5%, 2W, linear taper, 1/8 in. lg, slotted shaft, series 43	CM18924	Clarostat
R21	Resistor, fixed, WW, 76K ±1% 3W	Type P3W	Precision Resistor
R22	Resistor, fixed, WW, 3K ±1%, 1/2W	Type TX-178	Precision Resistor
R23	Resistor, variable, WW, 50K ±5%, 3W, linear taper, 1/4 in. dia., 1/2 in. lg, shaft, series 58 (Model 215A/AM/AK/AMK)	CM20403	Clarostat
R23	Resistor, variable, WW, 100K ±5%, 4W, linear taper, 1/4 in. dia., 1/2 in. lg, shaft, series 10, (Model 218A/AM/AK/AMK)	CM18927	Clarostat
R24	Resistor, variable, WW, 10K ±5%, 2W, linear taper, 1/4 in. dia., 1/2 in. lg, shaft, series 43	CM21189	Clarostat

REFERENCE SYMBOL	DESCRIPTION	TYPE OR PART NO.	MANUFACTURER
R25	Resistor, fixed, WW, ceramic, 25K ±5%, 10W	'Koolohm'10KT25K	SPRAGUE
R26	Resistor, fixed, comp, 4.7 ±5%, 1W	GB-47G5	Allen-Bradley
R27	Resistor, fixed, comp, 4.7 meg ±10%, 1/2W	EB-4751	Allen-Bradley
R28,29,30,37, 38,39,46,47, 48,55,56,57, 64,65,66,73, 74,75	Resistor, fixed, comp, 10 ±10%, 1W	GB-1001	Allen-Bradley
R31,32,33,40, 41,42,49,50, 51,58,59,60, 67,68,69,76, 77,78	Resistor, fixed, comp, 470 ±10%, 1W	GB-4711	Allen-Bradley
R34,35,36,43, 44,45,52,53, 54,61,62,63, 70,71,72,79, 80,81	Resistor, fixed, comp, 82 ±10%, 1W	GB-8201	Allen-Bradley
R82-87	Resistor, fixed, WW, 1 ±5%, 1W	BW1	Int'l Resistance
R88	Resistor, fixed, WW, vitreous enamel, 3 ±5%, 20W	20F3	Ward Leonard
RT1	Ballast tube (215, 218A/AM)	AMP 3-4	Amperex
S1	Switch, toggle, SPST	160-73	Carling Electric
S2	Switch, toggle, TPDT	HL233-73	Carling Electric
S3	Switch, toggle, DPST	2BK-62-73	Carling Electric
T1	Transformer, power	5019	EMC
T2	Transformer, filament & power	5020	EMC
TB1	Barrier strip, 3 terminal	3-141-Y	Cinch Jones
TB2	Barrier strip, 5 terminal (rear termination only)	5-141-Y	Cinch Jones
V1, 2	Electron tube	NL615	Nat'l Electronics
V3, 5	Electron tube	OA2	RCA
V4, 6	Electron tube	OB2	RCA
V7, 8	Electron tube	85A2/OG3	Amperex
V9	Electron tube	12AX7	RCA
V10	Electron tube	6AU6	RCA
V11	Electron tube (215, 218A/AM)	12AX7	RCA
V11	Electron tube (215, 218AK/AMK)	12AY7	G.E.
V12-29	Electron tube	6550 or KT88	Tung-Sol British Ind.
V30, 31	Electron tube	EM-10	EMC
XDS1	Holder assembly, pilot bulb, green faceted lens	100	Drake Mfg.
XDS2	Holder assembly, pilot bulb, red faceted lens	100	Drake Mfg.
XF1, 2	Extractor post, fuse, miniature	342003	Littelfuse
XV1, 2	Socket, 4 prong	77-M1P4	Amphenol
XV3,XV8,XV10	Socket, 7 pin, miniature	53P24022	Cinch Jones
XV9, 11	Socket, 9 pin, noval	14502	Cinch Jones
XV12, -XV29	Socket, 8 pin, octal	9751-9	Cinch Jones

Manufacturer's part numbers are indicative of stock employed at the time of compilation of this parts list. Unless otherwise noted, and except for Electronic Measurements (EM) part numbers, equivalent parts may be used for replacement.

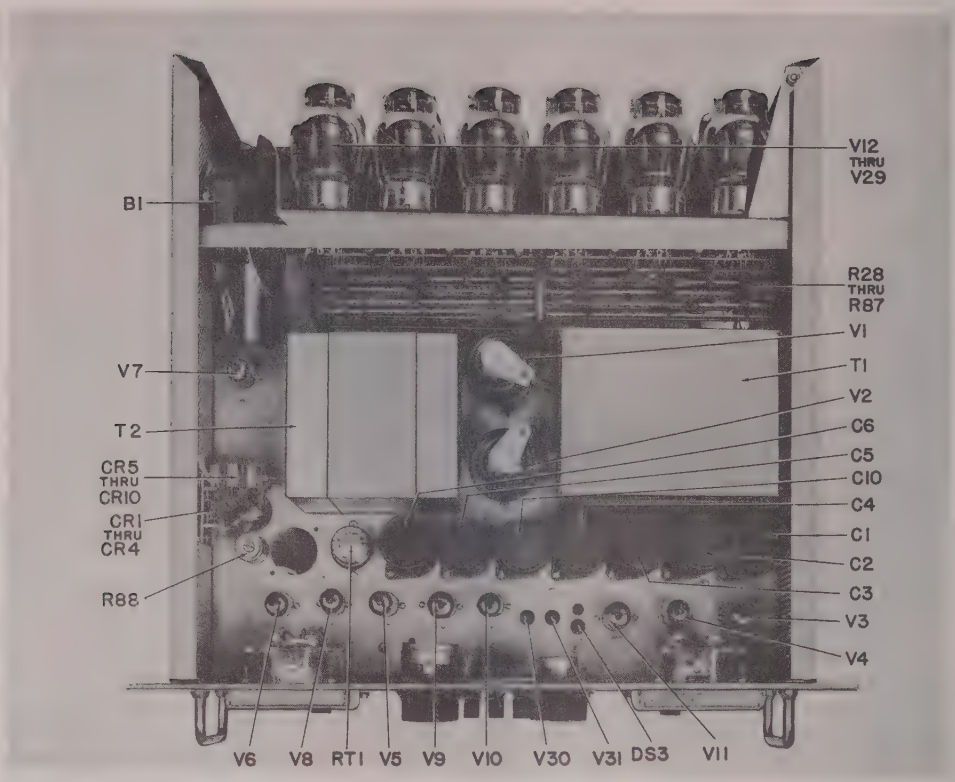


Figure 5-1. Parts Locations, Top View

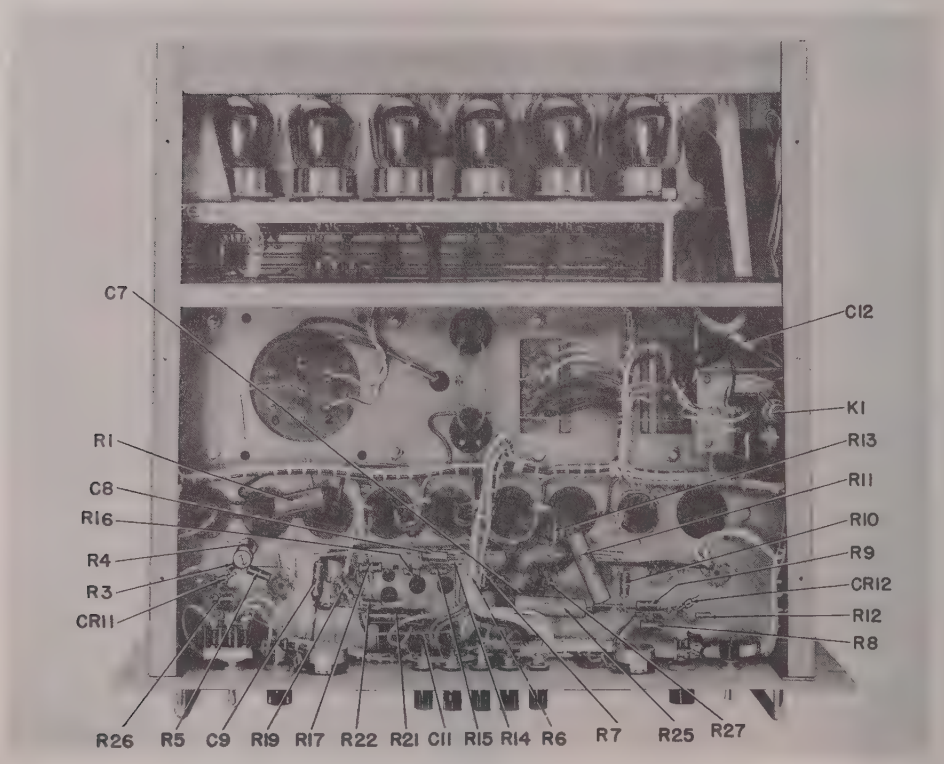


Figure 5-2. Parts Locations, Bottom View

PARTS LIST

10/62

MODELS 215A/AK, 218A/AK

PROGRAMMING CONSTANT:
1000 ohms-per-volt
115 volts, 50-60 CPS input

REFERENCE SYMBOL	DESCRIPTION	TYPE OR PART NO.	MANUFACTURER
B1	Motor, shaded pole, 115V, 50-60 CPS, 6 in. fan blade	DYAB-570-3	Barber-Colman
*C1,2,3,4,10	Capacitor, electrolytic, 320µf, 300 VDC, insul. sleeve	D31962	Sprague
*C5,6	Capacitor, electrolytic, 80µf, 450 VDC, insul. sleeve	D15911	Sprague
C7	Capacitor, mica, 100µµf ±5%, 500 VDC	CM20B101J	Micamold
C8	Capacitor, mica, 220µµf ±5%, 500 VDC	CM20B221J	Micamold
*C9	Capacitor, electrolytic, 25µf, 25 VDC, insul. sleeve	KE25/25	Frako
C11	Capacitor, mylar, 0.5µf ±20% -10%, 400 VDC	Type 211OBM	Chicago
C12	Capacitor, mica, 15µµf ±5%, 500 VDC	CM20B150J	Micamold
CORD	Line cord, 6'8" lg., #14 gauge, 3 cond., 3 prong plug	328-B-101	EMC
*CR1,2,3,4,13	Rectifier, silicon	CER71	Solitron
CR5-CR10	Rectifier, selenium	8J1	Radio Receptor
*CR11,12	Diode, silicon	HC69	Solitron
*DS1,2	Lamp, 6.3V, 0.25A	44	G.E.
*DS3	Lamp, neon	NE-2	EMC
E1,2	Post, binding, red	29-3R	Grayhill
E3,4,5	Post, binding, black	29-3B	Grayhill
E6	Shorting link	938-L	General Radio
E7	Shorting link	141-J	Cinch-Jones
*F1	Fuse, cartridge, 15A	3AG15	Sightmaster
*F2	Fuse, cartridge, 3A	3AG3	Sightmaster
J1,J5-10	Tip jack, nylon, black	105-603	E.F. Johnson
J3	Socket, octal (stabilizer unit or ballast tube)	9751-9	Eby
J4	Tip jack, nylon, red	105-602	E.F. Johnson
K1	Time delay relay, DPST, 115V, 60 CPS	328-D-80	EMC
M1	Ammeter, 0-3 ADC ±2% full scale	Model 653/A3	EMC
M2	Voltmeter, 0-50 VDC ±2% full scale (Model 215 A/AK)	Model 653/V50	EMC
M2	Voltmeter, 0-100 VDC ±2% full scale (Model 218 A/AK)	Model 653/V100	EMC
R1	Resistor, fixed, WW, ceramic, 20K ±5%, 5W	5KT20K	Sprague
R2,3,12	Resistor, fixed, comp., 1 megohm ±10%, 1/2W	EB-1051	Allen-Bradley
R4	Resistor, fixed, WW, vitreous enamel, 10K ±5%, 20W	Type'Brown Devil'	Ohmite
R5	Resistor, fixed, comp., 5100 ±5%, 1W	GB-5125	Allen-Bradley
R6	Resistor, fixed, comp., 390K ±10%, 1/2W	EB-3941	Allen-Bradley
R7	Resistor, fixed, comp., 330K ±10%, 1/2W	EB-3341	Allen-Bradley
R8	Resistor, fixed, comp., 5600 ±5%, 1W	GB-5625	Allen-Bradley
R9	Resistor, fixed, comp., 3600 ±5%, 1W	GB-3625	Allen-Bradley
R10	Resistor, fixed, comp., 22K ±10%, 1W	GB-2231	Allen-Bradley
R11	Resistor, fixed, WW, ceramic, 4000 ±5%, 10W	10KT4K	Sprague
R13,19	Resistor, fixed, comp., 220K ±10%, 1W	GB-2241	Allen-Bradley
R14,15	Resistor, fixed, comp., 100K ±10%, 1/2W	EB-1041	Allen-Bradley
R16	Resistor, fixed, comp., 330K ±10%, 1/2W	EB-3341	Allen-Bradley
R17	Resistor, fixed, comp., 150K ±10%, 1W	GB-1541	Allen-Bradley
*R18	Resistor, variable, WW, 3000 ±5%, 2W, linear taper, 1/4 in. dia. by 1/8 in. lg. slotted shaft. Series 43	CM18923	Clarostat
*R20	Resistor, variable, WW, 10K ±5%, 2W, linear taper, 1/4 in. dia. by 1/8 in. lg. slotted shaft. Series 43	CM18924	Clarostat
*R21	Resistor, fixed, WW, 76K ±1%, 3W	P3-W	Precision Resistor
*R22	Resistor, fixed, WW, 3000 ±1%, 1/2W	Type TX-178	Precision Resistor
*R23	Resistor, variable, WW, 50K ±5%, 3W, linear taper, 1/4 in. dia. by 1/2 in. lg. shaft. Series 58 (215A/AK)	CM20403	Clarostat
*R23	Resistor, variable, WW, 100K ±5%, 4W, linear taper, 1/4 in. dia. by 1/2 in. lg. shaft. Series 10 (218A/AK)	CM18927	Clarostat
*R24	Resistor, variable, WW, 10K ±5%, 2W, linear taper, 1/4 in. dia. by 1/2 in. lg. shaft. Series 43	CM21189	Clarostat
R25	Resistor, fixed, WW, ceramic, 25K ±5%, 10W	10KT25K	Sprague
R26	Resistor, fixed, comp., 4.7 ±5%, 1W	GB-47G5	Allen-Bradley
R27	Resistor, fixed, comp., 4.7 megohms ±10%, 1/2W	EB-4751	Allen-Bradley
R28,29,30,37, 38,39,46,47, 48,55,56,57, 64,65,66,73, 74,75	Resistor, fixed, comp., 10 ±10%, 1W	GB-1001	Allen-Bradley
R31,32,33,40, 41,42,49,50, 51,58,59,60, 67,68,69,76, 77,78	Resistor, fixed, comp., 470 ±10%, 1W	GB-4711	Allen-Bradley
R34,35,36,43, 44,45,52,53, 54,61,62,63, 70,71,72,79, 80,81	Resistor, fixed, comp., 82 ±10%, 1W	GB-8201	Allen-Bradley

PARTS LIST

MODELS 215A/AK, 218A/AK

(cont'd)

REFERENCE SYMBOL	DESCRIPTION	TYPE OR PART NO.	MANUFACTURER
R82-87	Resistor, fixed, WW, 1 ±5%, 1W	BW1	International Resistance
R88	Resistor, fixed, WW, vitreous enamel, 3 ±5%, 20W	20F3	Ward Leonard
*RT1	Ballast tube (215, 218A/AM)	AMP 3-4	Amperex
*S1	Switch, toggle, SPST	160-73	Carling
*S2	Switch, toggle, TPDT	HL233-73	Carling
*S3	Switch, toggle, DPST	2BK62-73	Carling
T1	Transformer, power	5019	EMC
T2	Transformer, filament and power	5020	EMC
TB1	Barrier strip, 3 terminal	3-141-Y	Cinch-Jones
TB2	Barrier strip, 5 terminal (rear termination only)	5-141-Y	Cinch-Jones
*V1,2	Electron tube	NL615	National Elects
*V3,5	Electron tube	0A2	RCA
*V4,6	Electron tube	0B2	RCA
*V7,8	Electron tube	85A2/0G3	Amperex
*V9	Electron tube	12AX7	RCA
*V10	Electron tube	6AU6	RCA
*V11	Electron tube (215,218A)	12AX7	RCA
*V11	Electron tube (215,218AK)	12AY7	G.E.
*V12-29	Electron tube	6550 or KT88	Tung-Sol British Ind.
*V30,31	Electron tube	EM-10	EMC
XDS1	Holder assembly, pilot lamp, green faceted lens	100	Drake
XDS2	Holder assembly, pilot lamp. red faceted lens	100	Drake
XF1,2	Extractor post, fuse, miniature	342003	Littelfuse
XV1,2	Socket, 4 prong	77-M1P4	Amphenol
XV3-XV8,10	Socket, 7 pin, miniature	53P24022	Cinch-Jones
XV9,11	Socket, 9 pin, noval	14502	Cinch-Jones
XV12-XV29	Socket, octal	9751-9	Eby

ELECTRICAL PARTS LIST
CHOPPER STABILIZER UNIT
336-A-32/349-A-17

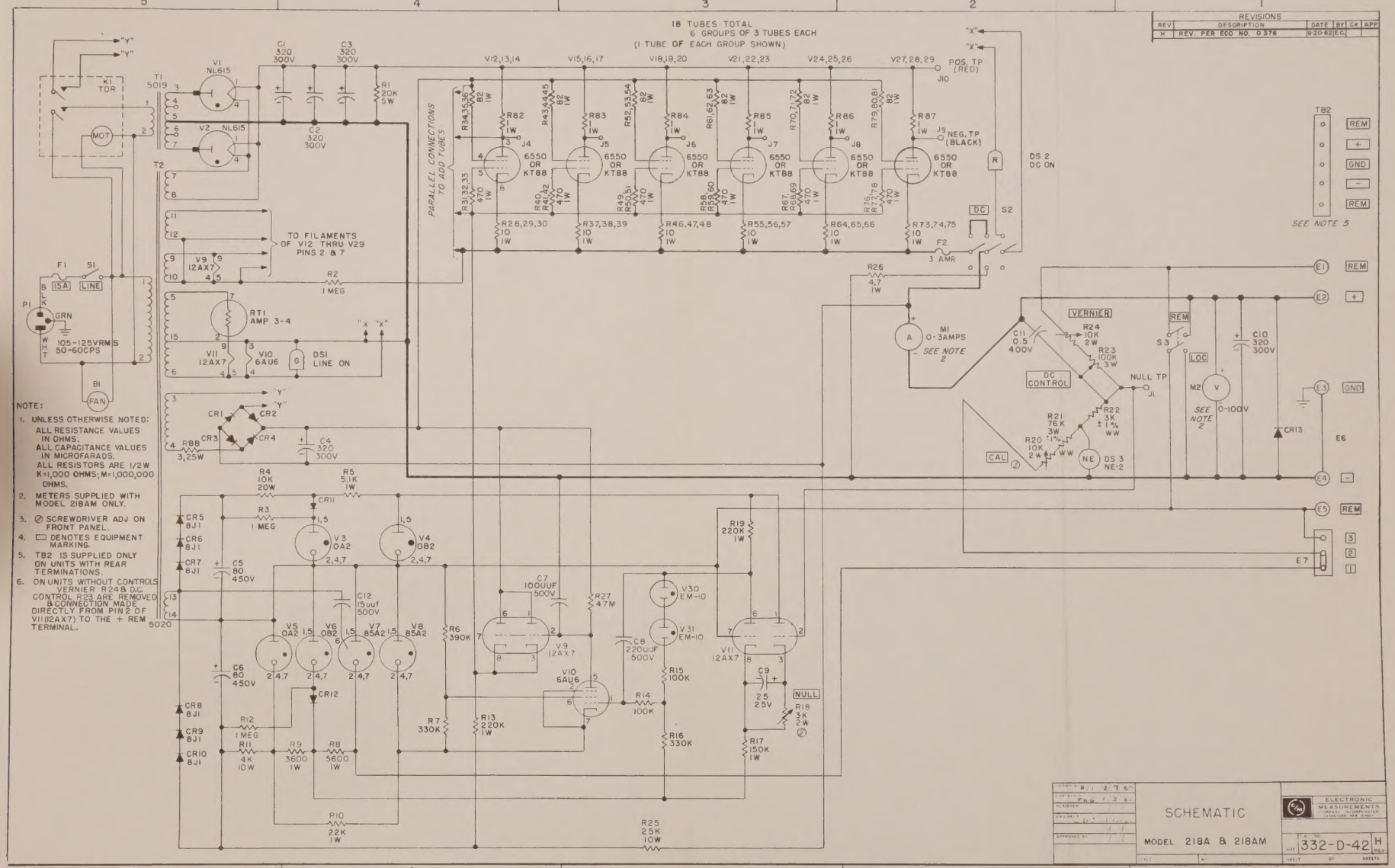
C1	Capacitor, mica, 27μμf ±5%, 500 VDC	CM19B270J	ARCO
C2,3,4	Capacitor, mylar, 0.022μf ±10%, 200 VDC	107-0.022/200	Pyramid
*C5	Capacitor, tantalum. etched foil, non polarized, 20μf ±20%, 25 VDC	TAE20-25SDLK-NP	Int'l Elect's..
*K1	Chopper, SPDT, 6.3V, 60 CPS	Model 175	AIRPAX
P3	Plug, octal	86-CP8	Amphenol
R1	Resistor, fixed, comp., 120K ±10%, 1/2W	EB-1241	Allen-Bradley
R2	Resistor, fixed, comp., 33K ±10%, 1/2W	EB-3331	Allen-Bradley
R3,6	Resistor, fixed, comp., 4.7 megohms ±10%, 1/2W	EB-4751	Allen-Bradley
R4	Resistor, fixed, comp., 100K ±10%, 1/2W	EB-1041	Allen-Bradley
R5,7	Resistor, fixed, comp., 680K ±10%, 1/2W	EB-6841	Allen-Bradley
R8	Resistor, fixed, comp., 56K ±10%, 1/2W	EB-5631	Allen-Bradley
R9	Resistor, fixed, comp., 270K ±10%, 1/2W	EB-2741	Allen-Bradley
R10	Resistor, fixed, comp., 1 megohm ±10%, 1/2W	EB-1051	Allen-Bradley
*V1	Electron tube	12AX7	RCA

PARTS LIST ADDENDUM 220 volts, 50-60 CPS 198-242 VRMS input range

B1	Motor, shaded pole, constant speed, 220 volts, 50-60 CPS, 6" fan blade	1075-3174	Howard
*F1	Fuse, cartridge, 8A	3AG8	Sightmaster
*S1	Same as for 115 volt version		
T1	Transformer, power	5095	EMC
T2	Transformer filament and power	5096	EMC

NOTES:

1. *ASTERISKED PARTS are recommended spares in quantity one per reference symbol, except fuses, which are three per reference symbol.
2. WHEN MAKING REPLACEMENTS: Part numbers are indicative of stock employed at the time of compilation of this list. Unless otherwise noted, and except for Electronic Measurements (E/M) numbers, "or equal" parts may be used for replacement. Electronic Measurements reserves the right to replace a part with an "or equal" part.
3. WHEN ORDERING PARTS FROM E/M: Include model and serial numbers of the instrument. Note carefully and include the letter suffix of any transformer number. In case of a discrepancy between a parts list number and the number actually printed on the part, employ the latter.
4. RECOMMENDED SPARES. When electrolytic capacitors are to be stored as spares for a year or more, request Technical Note 32.


18 TUBES TOTAL
6 GROUPS OF 3 TUBES EACH
(1 TUBE OF EACH GROUP SHOWN)
PARALLEL CONNECTIONS TO ADD TUBES
TO FILAMENTS OF V12 THRU V29 PINS 2 & 7
105-125VRMS 50-60CPS
SEE NOTE 5
DS 2 DC ON
3 AMP
0-3AMPS
SEE NOTE 2
VERNIER
DC CONTROL
NULL TP
0-100V
SEE NOTE 2
DS 3 NE-2
DSI LINE ON
NULL
CAL
POS. TP (RED)
NEG. TP (BLACK)
REVISIONS
REV. PER ECO NO. 0376
SCHEMATIC
MODEL 218A & 218AM
ELECTRONIC MEASUREMENTS
332-D-42
NOTE:
1. UNLESS OTHERWISE NOTED: ALL RESISTANCE VALUES IN OHMS. ALL CAPACITANCE VALUES IN MICROFARADS. ALL RESISTORS ARE 1/2W K=1,000 OHMS; M=1,000,000 OHMS.
2. METERS SUPPLIED WITH MODEL 218AM ONLY.
3. ⊘ SCREWDRIVER ADJ ON FRONT PANEL.
4. ▭ DENOTES EQUIPMENT MARKING.
5. TB2 IS SUPPLIED ONLY ON UNITS WITH REAR TERMINATIONS.
6. ON UNITS WITHOUT CONTROLS VERNIER R24 & D.C. CONTROL R23 ARE REMOVED & CONNECTION MADE DIRECTLY FROM PIN 2 OF V11 (12AX7) TO THE + REM TERMINAL.

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